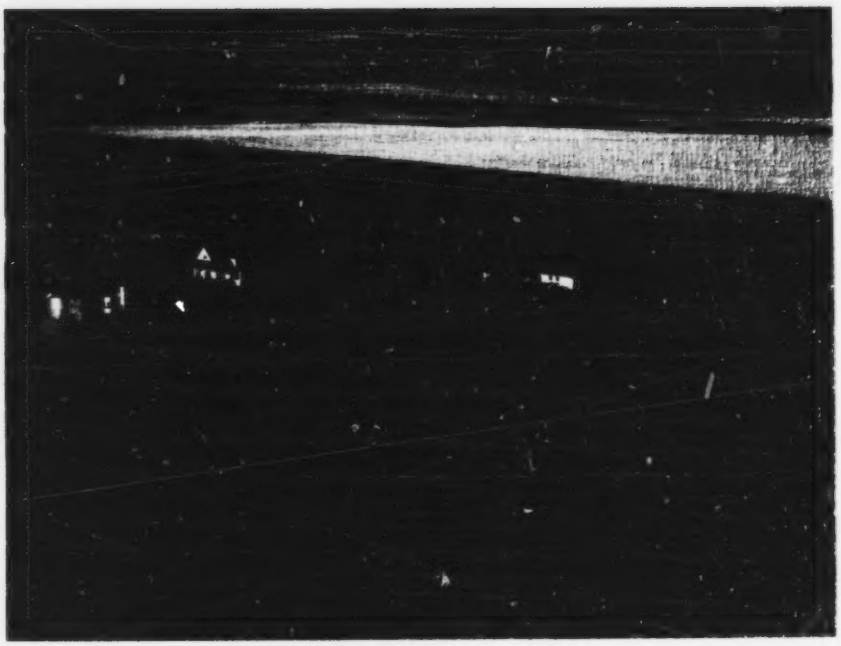
RESEARCH AND AGRICULTURAL PRODUCTIVITY IN ALBERTA

Alberta

ENVIRONMENT COUNCIL OF ALBERTA



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Research and Agricultural Productivity in Alberta

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Preface

The Environment Council of Alberta has been instructed by the Alberta government to enquire into means for maintaining and expanding Alberta's agricultural land base, and also to identify means for maximizing agricultural production. A series of background reports intended to stimulate public discussion of the many issues and concerns integral to this investigation have been prepared. Public hearings throughout the province will provide an opportunity for urban and rural Albertans to contribute to the development of policy options for the Alberta agricultural land base.

This report, *Research and Agricultural Productivity in Alberta,* has been prepared for the Environment Council of Alberta by Marv Anderson and Associates Limited, with assistance from Alberta Agriculture. The report provides an overview of agricultural research activities relevant to Alberta and considers the implications for future agricultural productivity.

The Environment Council of Alberta acknowledges the important contribution this report makes to its investigation; however, the views expressed in the paper are those of the author. The Council does not accept responsibility for statements or opinions given herein, and does not guarantee the accuracy of statistics or quotations presented.

Photos courtesy of Alberta Agriculture

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Introduction

This overview of research and productivity in Alberta's agricultural sector is one in a series of background papers prepared to facilitate discussion at Environment Council of Alberta public hearings on **Maintaining and Expanding the Agricultural Land Base in Alberta** for maximizing its production. The Terms of Reference for these hearings specifically ask:

What are the potential productivity opportunities based on agricultural research in livestock and other types of agricultural production?

To answer this question, this paper examines the relationship between research, technology and productivity.

The ratio of total production generated relative to the quantity and quality of **all** resources utilized in the production process (land, labour, machinery and equipment, other inputs and management) measures the total resource productivity or efficiency of the agricultural industry.* Agricultural output can be increased both by expanding the resource base and by increasing the intensity with which our resources are used. To achieve greater total resource productivity within Alberta's agricultural industry will essentially depend upon ongoing technological change, and this change, in turn, will largely depend upon research and the social-economic-institutional conditions which either encourage or discourage its practical application.

Therefore, we must ask:

- Will basic agricultural research be forthcoming?
- Will it be translated into usable technological advances?
- Will this technology be applicable to Alberta conditions, thus increasing the province's future total agricultural productivity?

Our examination of these and related questions is covered in the following sections:

Past Performance – The historical development of agriculture in Alberta is discussed. This review includes the structural changes that have occurred as agriculture has evolved from a labour-intensive to a capital-intensive industry. Past measures of change in agricultural productivity and examples of research breakthroughs that have increased productivity are identified.

The Research Establishment – Major research institutions and facilities in Alberta are identified. The importance of each institution and the focus of its current research efforts are indicated.

Research Payoffs and Potential – The payoff from past agricultural research efforts is examined. In addition, some examples of 'frontier' research are discussed.

Projected Productivity Trends – The anticipated growth of agriculture is examined, and methods for achieving this growth are discussed. While opinions vary, the consensus seems to favor continued growth during the next 5-10 years.

Related Issues – Issues that focus on different types of costs and benefits of technological change to agriculture and society in general are briefly discussed.

Summary, Concerns and Implications – This section lists what the authors feel are the major areas of interest and concern related to agricultural research and future agricultural productivity in Alberta.

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* The reader is strongly urged to avoid thinking of agricultural productivity in terms of partial productivity measures, such as yield per acre, output per worker, rate-of-gain per ton of feed, or output per dollar invested. At best, these measures only indicate long-term total productivity trends.

Past Performance

Proper appreciation and use of facts will convince the most sanguine that the larger portion of this [Palliser Triangle] area is, in its present state, unfit for the permanent habitation of man, on account of climate. soil and lack of fuel.

This description by explorers John Palliser and Henry Hind in 1857 of a part of southern Alberta covering almost six million acres appears very dated today. During the past 125 years, our appreciation of the area's potential has changed dramatically.

Early settlement involved labour-intensive and largely self-sufficient farm units where each farm worker produced enough food for three to five people. Today, large-scale, capital-intensive farm units now produce enough food for fifty people per worker. This large increase in production can largely be attributed to technological change: changes in what inputs are used and the intensity with which resources are employed. Over time, the combination of new technology and high rates of capital investment have made the irrigated portions of the Palliser Triangle one of Alberta's most productive regions.

Accompanying technological advances has been structural change in Alberta's agricultural sector. Since the 1940s, the province's farm population has been declining. While farms have grown larger, farm numbers have fallen. Many inputs once furnished on the farm (e.g., energy) are now purchased. The capital value of farms has increased, due both to a greater reliance on agricultural machinery and to rising real land values, particularly during the 1970s. At the same time, cultivated acreage and the real value (constant dollars) of crops and livestock produced have increased. These changes in Alberta's agriculture have closely paralleled changes in other parts of Canada and the United States.

Undoubtedly, the shift to a more capital-intensive agriculture has increased total agricultural productivity. For example, agricultural productivity in the United States was estimated to have increased by 1.2 and 1.6 percent per annum over the periods 1925-1950 and 1950-1976, respectively. Canadian research suggests that total productivity growth in western Canadian agriculture during 1962-1978 averaged about 1.7 percent per annum. In another study, average annual agricultural productivity growth rates in Canada between 1950 and 1969 were estimated to have been even higher, perhaps 1.9 percent per year (see Table 1). This latter increase was the net effect of an average annual growth rate of 2.3 percent in farm output and an annual growth of 0.4 percent in the volume of inputs used.

While some disagreement exists, the general consensus is that past growth in agricultural productivity has been strongly positive.

Table 1. Indices of Farm Output, Inputs and Total Productivity in Canada, 1950-1969 (1949 = 100)

Period	Farm Output	Production Input	Productivity Ratio
1950-54	120	95	126
1955-59	127	94	135
1960-64	140.5	96	147
1965-69	169	101	166.5
Annual Growth Rates			
1950-1969	+2.3%	+.4%	+1.9%
1960-1969	+3.6	+1.1	+2.5

Some of the most important technological changes over the past century which have resulted in these efficiency gains include:

- **Mechanical Power** – The substitution of machine power (tractors) for animal power was important for two reasons. First, machinery greatly expanded the capacity of farmers to do work, such as cultivating additional acreage. Second, draft animals required feed; hence, the substitution of mechanical for animal power freed the production from thousands of acres for other uses. The impetus for many of these developments came from the internal combustion engine which relied on relatively inexpensive fossil fuels.

- **Hydraulic and Electrical Engineering** – Paralleling mechanical developments, advances in hydraulics and transmission of electric power allowed further reduction in farm labour and draft power. The trend continues today with agricultural applications of hydraulically-driven motors and micro-electronics which are now used in such devices as grain bin cleaners and combine grain loss monitors.

- **Structural Technology** – Advances in building construction (e.g., storage facilities) and other farm-related structures (e.g., irrigation and drainage techniques) have contributed significantly to increasing agricultural productivity.

- **Biological Technology** – The development of crops which can produce well in a prairie environment (e.g., Marquis wheat circa 1909) were obviously very important to the opening up of the Canadian West. Success in improving canola varieties, the development of artificial insemination techniques and the adoption of livestock crossbreeding are other developments which have been particularly important to increasing Alberta's agricultural productivity.

- **Chemical Technology** – The introduction and wide acceptance of chemical fertilizers, herbicides and pesticides have done much to maintain and increase crop yields. Development of chemical fertilizers has particularly been fostered by the availability of abundant (i.e., inexpensive) fossil fuel derivatives.

- **Infrastructural and Institutional Advances** – The complementary development and ongoing adjustment of publicly funded institutions and infrastructure allowed the agricultural industry, and, in fact, all of society, to more fully realize many of the potential productivity increases implicit in the foregoing examples. Examples of such change are numerous: transportation and communications infrastructure, agricultural education and extension services, marketing and other regulatory or facilitating agencies.

- **Land Use Changes and Adaptations** – Extensive settlement in Alberta is less than a century old. Initially, many inappropriate areas and inappropriate cropping patterns were utilized. As the climate, soil and topography became better understood by succeeding generations of farmers, a more appropriate mix of land use, crops and production practices were adopted leading to a better fit with land capabilities and higher productivity.

Plant research is conducted within most major climatic areas of Alberta: research plots located at Agriculture Canada's Lacombe Research Station (left); forage varietal testing at Agriculture Canada's Beaverlodge Research Station (centre); testing new pest controls at Alberta Agriculture's Horticultural Research Center in Brooks (right).

The Research Establishment

OVERVIEW

Agricultural research in Alberta is a small but integral part of the global agricultural research establishment. Perhaps one-quarter of one percent of the **world's** agricultural research is conducted in Alberta.

Nevertheless, having its own research capability is absolutely essential to Alberta's agricultural sector because the research undertaken specifically addresses the problems unique to the province's geographic location and resource base. Moreover, it is this research which will, in part, influence Alberta's future comparative advantage in national and international markets.

In this context it is useful to identify who is involved in agricultural research in Alberta, where they are located, and what they are doing.

At present, most agricultural research in Alberta is being conducted by:

- the federal government through Agriculture Canada
- the universities
- the Alberta Department of Agriculture
- the private sector

The location of all major public research facilities is indicated in Table 2. The relative contribution of each agency to the total agricultural research effort in Alberta is summarized in Table 3.

A total expenditure of about $30.0 million for agricultural research in Alberta in 1981-82 would represent about 1.0 percent of the province's 1980 cash receipts from the sale of farm products.

INSTITUTIONS

The long-term commitment to agricultural research in Alberta is evident when the research capabilities of each institution are examined in more detail.

Federal Government Agriculture Canada

Agriculture Canada has the largest agricultural research presence in the province, accounting for about one-half of the research effort in Alberta.

Much of the work is undertaken at the three federal research stations located at Lethbridge, Lacombe and Beaverlodge.

While Agriculture Canada continues to be the most heavily funded institution, its relative position in Alberta has been declining in recent years (Figure 1).

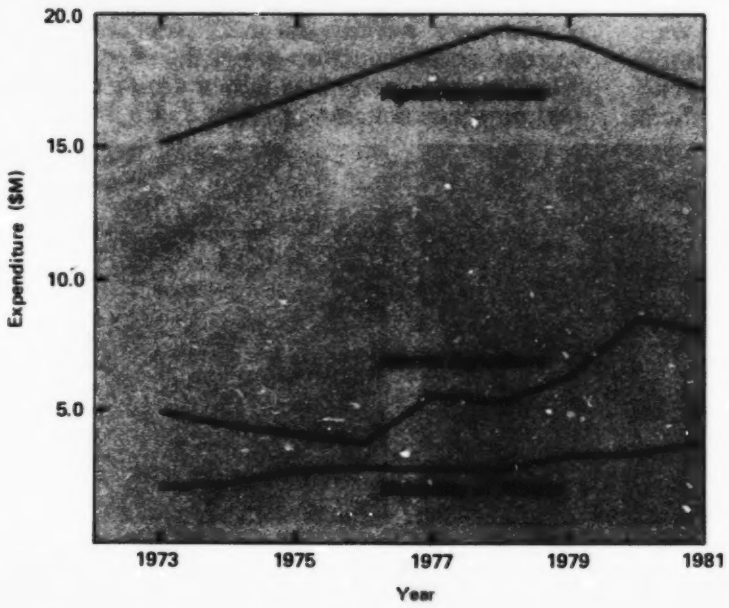


Figure 1

Real Agricultural Research Expenditures For Various Funding Institutions in Alberta, 1973 – 1981

(in 1981 dollars)

Table 2. Primary Public Research Facilities in Alberta, 1982*

Institution	Facility	Location	Research Focus
Agriculture Canada	Research Stations	Lethbridge	entomology/crops/irrigation/ soil and land management/dairy/beef/ poultry
		Lacombe	crops/swine/livestock fertility
		Beaverlodge	crop and land management (N. Alta.)
	Research Sub-stations	Vegreville	solonetzic soils
		Fort Vermilion	crop and land management (N. Alta.)
		Manyberries	beef/range management
University of Alberta	Research Stations	Edmonton	livestock/crop production
		Ellerslie	beef/crops
	George Lake Field Station	Barrhead	entomology
	University Ranch	Kinsella	beef breeding/range management
	Breton Plots	Breton	grey wooded soils
	Ministik Wildlife Research Area	Ministik Lake	wildlife research
	Devon Botanical Garden	Devon	plant introduction
Alberta Agriculture	Alberta Horticultural Research Center	Brooks	horticultural crops/special crops
	Field Crops Research Facility	Lacombe	crop breeding
	O.S. Longman Building	Edmonton	soil and feed testing/food and food quality testing/ veterinary services
	Food Processing Centre	Leduc	food processing development
	Poultry Research Centre	Oliver	poultry nutrition
	Alberta Tree Nursery and Horticultural Centre	Oliver	nursery stock/horticultural crop testing
	Artificial Insemination Centre for Swine	Leduc	swine breeding
	Bull Testing Station	Ellerslie	performance testing of beef
	Weather Modification Project (in conjunction with the Alberta Research Council)	Penhold	weather modification: hail suppression and rainfall enhancement
Alberta Environment	Alberta Environmental Centre	Vegreville	plant and animal environmental research

* Less significant but still noteworthy is research being conducted at the Universities of Calgary and Lethbridge and colleges at Olds, Vermilion and Fairview.

Table 3. Resources Committed to Agricultural Research in Alberta, 1980*

Institution	Professional Person-Years	Technical Person-Years	Total Research Funds ($M 1981/82)
Agriculture Canada	119	129	$17.0
Universities	100	90	3.9
Alberta Agriculture	73	118	8.0
Private Industry	9	14	1.2 (est.)
TOTAL	301	351	30.1

* Very approximate.

Across Canada, total Agriculture Canada expenditures on agricultural research and development have increased slowly in real terms during the past decade, averaging about $170 million per year in 1981 dollars.

In terms of total research effort, Agriculture Canada's Lethbridge facility is the most important. Of the 75.9 professional person-years devoted to agricultural research at Lethbridge in 1980, 14.3 (18.8%) were spent on research in apiculture/entomology, followed by 13.8 (18.2%) on cereals and oilseeds and 13.3 (17.5%) on land use and soils. Ruminant research was also important, accounting for 12.7 (16.7%) professional person-years. The remaining 21.8 person-years (28.8%) were devoted to research on forage crops, non-ruminants, processing/marketing/transportation and special crops.

At Lacombe, research efforts during 1980 focussed on cereals and oilseeds, ruminants, non-ruminants and processing/marketing/transportation. These four areas respectively involved 5.6 (29.6%), 4.0 (21.2%), 3.3 (17.5%) and 2.5 (13.2%) professional person-years, out of a total of 18.9 person-years. Research involving forages, land use and special crops accounted for the remaining 3.5 person-years (18.5%).

A great deal of the research effort at Beaverlodge is related to forage crops, cereals and oilseeds. These two areas accounted for 7.6 (53.5%) of a total professional effort of 14.2 person-years. Special crops research accounted for an additional 2.8 person-years (19.7%). The remaining 3.8 (26.8%) professional person-years were allotted to apiculture/entomology and land use and soils.

About 10 additional professional person-years of agricultural research were conducted by Agriculture Canada in facilities at other locations in Alberta.

Universities

Universities essentially have a three-pronged mandate: teaching, research and extension. Traditionally, the Canadian university complex has given first priority to training students in the agricultural sciences. It remains their most important endeavour: supplying trained agricultural scientists and agrologists takes precedence over involvement in research. Nevertheless, the basic research and agricultural extension services undertaken by these institutions is a significant benefit to the agricultural industry.

Over 90 percent of Alberta's university-based agricultural research is conducted at the Univer-

Research within Alberta's apiculture sector is attempting to produce bee strains with the ability to overwinter in the province. Success would eliminate the cost of importing bees each spring, reduce dependence on foreign suppliers, and lessen the possibility of importing new bee diseases.

Approximately one-sixth of the agricultural research conducted in Alberta is concerned with forage production.

sity of Alberta in Edmonton. In addition to laboratory and greenhouse facilities on campus, the Faculty of Agriculture and Forestry operates a number of off-campus research facilities in the Edmonton area (see Table 2).

Research funds are obtained mainly from Alberta Agriculture and Agriculture Canada and, to a much lesser extent, from provincial agricultural organizations.

Despite significant increases in research funds to the University of Alberta in recent years, the enrollment of Alberta residents in graduate programs in agriculture generally declined during the last decade.

The University of Alberta accounted for 93.3 of 100 professional person-years of agricultural research undertaken by all Alberta universities in 1980. Ruminant research received the greatest attention at the University of Alberta — 21.7 person-years (23.2%). Grains and oilseeds accounted for 17.9 person-years (19.2%), land use and soils involved 13.6 person-years (14.6%) and forage crops 11.9 person-years (12.7%). Apiculture/entomology and non-ruminant research together accounted for an additional 14.8 person-years (15.9%). Some 13.4 person-years (14.4%) were spent in processing/marketing/transportation, special crops and other research areas.

One-half of the 5.0 professional person-years devoted to agricultural research at the University of Calgary were directed to basic research in plants. The remaining 2.5 person-years were focused on ruminants and special crops. At the University of Lethbridge, all 1.4 professional person-years in agricultural research were spent in ruminant research.

Alberta Agriculture

Direct involvement in agricultural research by Alberta Agriculture was limited until the early 1960s. Before that time, responsibility for research was left mainly with the University of Alberta and the federal research stations. While many of Alberta Agriculture's current research activities essentially supplement or augment the efforts of other research institutions, the Department's overall research program has become much more visible.

Improving the survival rate of piglets would greatly increase productivity among Alberta swine producers.

Of the 73 professional person-years of agricultural research conducted by Alberta Agriculture in 1980, approximately 50 percent were directed toward the areas of land use/soils and special crops — 19.5 and 16.8 person-years, respectively. Cereals, oilseeds and ruminant research together accounted for almost 16 professional person-years (21.8%). The remaining 20.8 professional person-years (28.5%) was utilized in apiculture/entomology, forages, non-ruminants, processing/marketing/ transportation and other areas.

Alberta Agriculture is also involved with producer groups and individual producers in various cooperative research activities. These range from regional crop varietal trials and demonstrations to consumer-oriented research projects.

Alberta Agriculture actively conducts and supports research in all major sectors that comprise or compromise the province's agricultural industry; for example, veterinary science (left), insect biology (centre), and crop science (right).

Alberta Agriculture presently has five major sources of research support. These include Farming for the Future, divisional and general departmental research funds, the Alberta Agricultural Research Trust, the Horned Cattle Trust and the Alberta Hail Project. The most important is the Farming for the Future program, with estimated expenditures of $6.4 million in 1982/83.

The Farming for the Future program was announced in 1977 with a funding commitment of $10 million from the Alberta Heritage Savings Trust Fund. In November 1980, an additional $15 million was allocated to the program from the Heritage Fund. These funds are expected to be exhausted when the program's mandate ends in March 1984.

The stated goals of the program are to improve the net income of Alberta farmers and to enhance the overall viability of Alberta's agricultural industry. Under the program, research funds are made available to both private industry and public institutions, provided that the proposed research meets the program's Terms of Reference established by the Agricultural Research Council of Alberta, the administrator of Farming for the Future.

The Farming for the Future program has recently been expanded to include an On-Farm Demonstration Program and a Graduate Student Research Support Program. However, according to recent studies by Alberta Agriculture, shortages of capital facilities and trained agricultural scientists will probably be significant limiting factors to any substantial expansion of agricultural research and scientific services in the future.

Private Industry

At present, private industry contributes only a small percentage of the total agricultural research carried out in the province. Much of its research effort has a strong production orientation. For example, a number of small firms operating in Alberta have successfully developed and marketed grain dryers, electronic monitoring equipment and tillage implements, as well as other specialized machinery. However, much of the basic technology being utilized is developed elsewhere, largely the USA and Europe, and is then imported into Canada by commercial interests. Innovative farmers throughout the province also continue to adapt machinery and farming techniques to better suit local farming conditions.

A number of private producer organizations are now involved in applied research and demonstration. The recent establishment of the Western Grains Research Foundation, with sponsorship from large farm organizations such as the Alberta and Saskatchewan Wheat Pools, United Grain Growers, the Canadian Federation of Agriculture and other organizations, will contribute additional research capability.

In 1980, forage crop and cereal/oilseed research together accounted for over 50 percent of the 9.0 professional person-years in private agricultural research. All other research areas each received less than 1.0 person-year of effort.

Research Payoffs and Potential

PAYOFFS

There is overwhelming evidence that agricultural research is a profitable long-term investment. Research is a necessary (although on its own not necessarily sufficient) condition for future productivity gains in agriculture. Since research benefits frequently spill over to society-at-large, the future growth and development of Alberta's agricultural sector should continue to depend heavily on **public** research facilities, manpower and funding.

No studies have as yet been undertaken to determine the returns to agricultural research in Alberta. The findings for other areas, however, indicate that returns are high (see Table 4); often much higher than returns to other investments. The estimates of annual returns presented in Table 4 are for all of agriculture as a whole. The calculations generally ignore any social-environmental costs which might have been involved. Some isolated success stories indicate even higher annual returns to research are possible. For example, canola research undertaken in Canada between 1960 and 1975 reportedly yielded a 95-110 percent return per annum. At least two dozen other studies on the return to agricultural research which all document relatively high payoffs have been catalogued.

Past success does not guarantee success in the future. At the same time, there is no reason to believe future research efforts will not generate acceptable (market) rates of return.

Yet, despite the historically high rates of return generated by agricultural research, funding for ongoing research in Alberta and elsewhere may continue to be undervalued by the public. This is generally the case when demand for agricultural commodities is growing slowly and most research gains are passed on to consumers in the form of lower food prices. The rising cost of the non-agricultural components of the current "food basket", e.g. packaging, heavily processed foods, etc., can also obscure the real value of these benefits to the consumer.

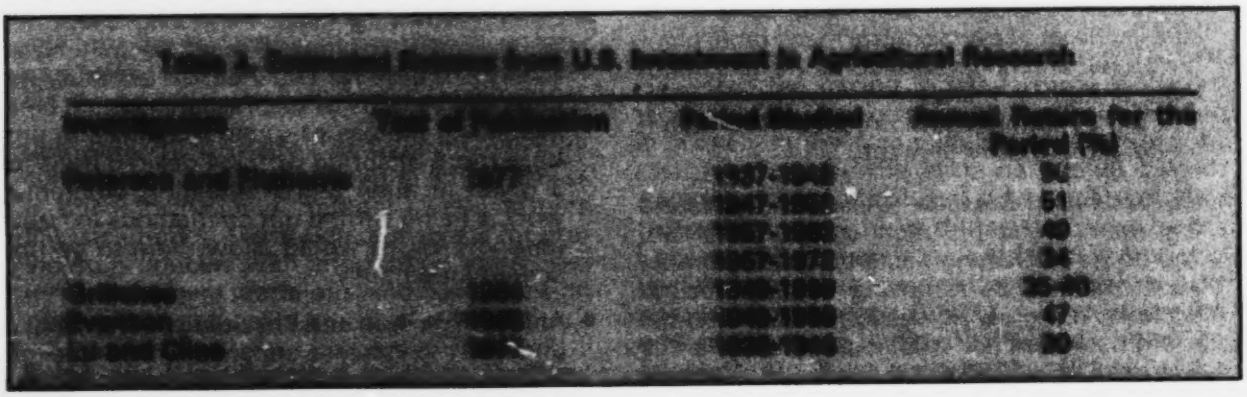
FRONTIER RESEARCH

Can major technological advances be expected in the future or have we reached a plateau?

Although answers to these questions will not be apparent for some time, it is obvious that a great number of promising "frontier" research projects could eventually result in large increases in our agricultural production potential.

Crop Production

- **Increased Nitrogen Fixation by Legumes** – Through recent research the capability of soybeans and their root nodules to fix nitrogen has been increased more than 500 percent. To date, success has only been achieved in controlled environments such as greenhouses. If this application could be transferred to field production of crops grown in Alberta, yields would increase significantly, with much of the



nitrogen coming from the air rather than from fertilizer or the soil.

- **Development of Nitrogen-Fixing Cereal Crops** – Cereals such as wheat, barley, oats and corn are unable to fix nitrogen from the air and must obtain it from the soil and chemical fertilizers. Success in research aimed at instilling cereals with the ability to fix nitrogen from the air would result in savings of millions of dollars annually to producers since fertilizer requirements would be reduced. However, no field-usable breakthroughs are anticipated in the next 5-10 years.

- **Pest Control** – Pest management strategies that employ resistant plant varieties, sex attractants, insect juvenile hormones, pheromones and other biological controls are being investigated. For example, insect juvenile hormones and pheromones are synthesized by the insects themselves. Hormones may be used to interfere with the normal growth of insects while pheromones interfere with the communication system used by many insects. Benefits would be expected to accrue from a reduction in environmental hazards associated with pesticide use and from reduced input costs to producers.

- **New Crops** – While there are more than 3,000 food plant species, less than one-half of one percent of them are used to feed the majority of the world's people. Plant breeding and selection among little used or unused crops could produce major benefits, especially for the less favorable agricultural areas of Alberta.

- **Bioregulators** – The potential of bioregulators to enhance agricultural productivity is considerable. Growth regulators can speed germination, induce or prevent plant flowering, increase size, increase branching, promote or delay senescence and control many other plant functions. Should interest continue in expanding agriculture in northern Alberta, research into bioregulators could produce major benefits to aid this development.

- **Ice-Nucleating Bacteria** – Research has found that many crops, including canola, are inhabited by ice-nucleating bacteria which promote ice formation. By removing these particular bacteria, the growing season for many crops could be extended. This could become a key factor in agricultural expansion in northern Alberta where the ability to artificially extend the growing season would be critical.

- **Drought and Salinity Resistance** – Some success has already been achieved in developing barley varieties which are more tolerant of saline conditions. A new barley variety known as Composite Cross XXXIX was recently tested in southern U.S. conditions and was found to produce economical yields with relatively lower requirements for water and plant nutrients. This coastal-type barley, unfortunately, has not been successful in Alberta's climate. If such a barley could be successfully bred for the province, it could have important implications for agriculture in semi-arid regions or where soils have a high salinity content.

- **Plant Structure** – Some cereal grains such as wheat are relatively inefficient users of solar energy because the grain at the top of the plant shades the working leaves from the sun. Changing the physical structure of these crops could result in large gains in production.

- **Plant Antibiotics** – Within the soil there are microorganisms which are both beneficial and harmful (pathogens) to plant growth. Scientists are examining the possibilities of inoculating the soil with naturally occurring bacteria that will act as antibiotics and overwhelm soil pathogens thereby encouraging greater plant growth.

- **Chemical Weed Control** – Continued research is expected to provide farmers with improved herbicides. Two promising but as yet unregistered chemicals are: (1) Lontrel which is effective against Canada thistle and can be used on canola, and (2) Poast which kills grassy weeds in broadleaf crops.

Livestock Production

- **Embryo Splitting** – Researchers have reported the successful cloning of a calf by splitting an embryo to produce two identical animals. The potential benefits of this research would be in increasing the use of superior animals to produce more offspring with the desired traits for a given location and/or situation. Additional work is being carried out on methods to freeze embryos which would allow them to be preserved indefinitely.

- **Animal Nutrition and Physiology** – Research is underway to increase understanding of the role of micro-nutrients in animal diets. Related research is attempting to define how the rumen in cattle functions and how cattle growth

mechanisms are regulated. Research in any of these areas could potentially result in greater production and more efficient livestock feed conversion.

- **Multiple Births** – Using techniques such as scientific selection, induced multiple ovulation and embryo transfer, greater emphasis is being placed on multiple births in cattle and sheep. The ability to transfer embryos from superior females to those of lower quality has been available for several years. The perfection of all of these techniques will accelerate genetic improvement in livestock.

Multiple birthing, embryo transplants and simple improvements in everyday herd health are some of the numerous avenues available to improve productivity in Alberta's livestock industry.

Related Research

- **Microwave Vacuum Grain Drying System** – This experimental grain drying system has been undergoing tests for several years. Testing has indicated it has a number of advantages over conventional systems. Microwave grain drying is quicker (as much as 50 times faster for rice) and can be performed at relatively low temperatures (40°C) while maintaining grain quality.

- **Computer Technology** – As knowledge in agriculture grows so too will the need for access to this information. Computer use by farmers is in its infancy. Great potential exists for providing producers with information to be used in management decisions and for extension purposes.

- **Solar- and Wind-Powered Irrigation Systems** – While the technology is already in existence, no major shift to these types of systems is anticipated in the near future if the relative cost of conventional energy remains largely unchanged. There is, however, some indication that wind power may presently be feasible in specific cases. Irrigation is an example. First, irrigation pumping requires a considerable supply of energy. Second, solar energy is compatible with irrigation in that the maximum need for irrigation occurs at times when and in locations where solar radiation is highest.

- **Moisture Sensor** – The United States Department of Agriculture (USDA) and the U.S. National Aeronautics and Space Administration (NASA) have begun work on developing soil moisture sensors. The ultimate goal is to develop a remote water detecting system that can sense soil moisture and crop conditions from satellites orbiting the Earth. This could be of substantial benefit in improving flood forecasts and in identifying areas threatened by drought. Such information, in conjunction with that provided by infrared photography, would be invaluable for forecasting current production/marketing conditions. At the farm level, the use of neutron probes as moisture sensors would be particularly beneficial to those involved in irrigation farming.

- **Weather Modification** – Considerable research is underway in Alberta to gain a better understanding of the precipitation process. Experiments have shown that seeding clouds with silver iodide or dry ice particles produces measurable effects within those clouds. Essentially, the process increases many times over the number of particles available for bonding with moisture in the air. The eventual goals are to reduce hail damage to crops and to increase rainfall and winter snowpack.

This listing is only intended to illustrate new benefits research may offer agriculture in the future. However, the strong thrust towards biological technology has two major implications. First, it is unlikely future technological advances will be characterized by the extreme capital bias or dependence on fossil fuel energy so typical of technological advances during the last 40 years. Second, this research re-orientation would suggest that advances in agricultural technology have not reached a plateau. At the same time, the existence of new technologies does not guarantee their adoption nor does it assure that the new technologies will be necessarily "good" for the agricultural land base over the longer term.

Projected Productivity Trends

OVERVIEW

There are no readily available estimates of total agricultural productivity for the Province of Alberta. We can only deduce that productivity growth in Alberta has, at least up until now, probably paralleled that in other parts of Canada and the United States:

CANADA

1950-59 ⟶ +1.9% per year

1960-69 ⟶ +2.5% per year

1962-78 ⟶ +1.7% per year

U.S.A.

1950-76 ⟶ +1.6% per year

SHORT-TERM INDICATORS

In the short term, however, simple trend line extrapolations of yield increases in Alberta during the period of 1961 to 1980 are probably indicative of what might be expected during the 1980s:

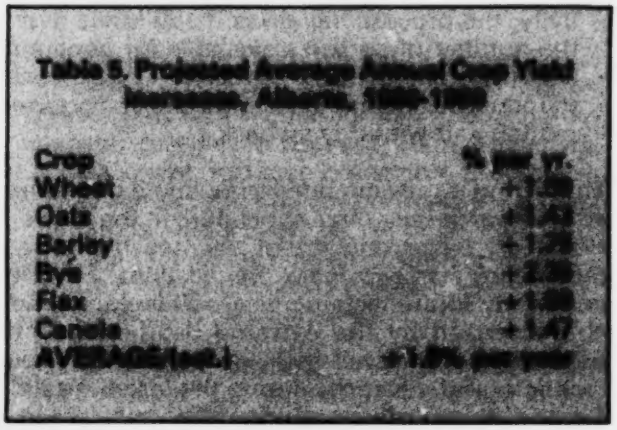


Table 5. Projected Average Annual Crop Yield Increases, Alberta, 1980-1989

Crop	% per Yr.
Wheat	+1.39
Oats	+1.43
Barley	+1.28
Rye	+2.00
Flax	+1.89
Canola	+1.47
AVERAGE(est.)	+1.5% per year

Clearly, these historic partial productivity measures are not necessarily comparable to future (short-term) total productivity changes in agriculture in Alberta. But they are at least suggestive.

Additional data also suggest how these expected yield increases might be achieved. For example, a study by D. Leisle presented at the Prairie Production Symposium at the University of Saskatchewan in 1980 indicates that varietal improvements are unlikely to augment aggregate production levels by more than one-half of one percent per year during the 1980s (see Table 6).

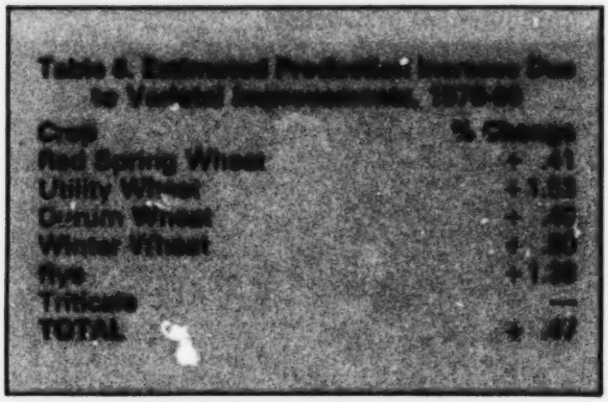


Table 6. Estimated Productivity Increase Due to Varietal Improvements, 1970-80

Crop	% Change
Red Spring Wheat	+ .31
Utility Wheat	+1.03
Durum Wheat	+ .45
Winter Wheat	+ .30
Rye	+1.39
Triticale	—
TOTAL	+ .47

In terms of the total yield increases expected (say, 1.5% per year), this would suggest that other yield-increasing technology would be expected to play a major role in agriculture for at least another 10 years. That is:

Varietal Improvements – 0.5% per year

Other Technology – 1.0% per year

AVERAGE YIELD INCREASE – 1.5% per year

This "other technology" is generally perceived as coming from more intensive application of existing technologies. Greater use and more efficient placement and timing of chemical fertilizer could account for up to 90 percent of the total projected increase in crop yields during the next 5-10 years.

Therefore, in the short run it is readily apparent that there is still an opportunity to expand production by increasing yields through existing technologies although likely at a diminishing rate. Essentially, this would involve closing the prevailing gap between current average farm yields and potential farm yields (see Figure 2). Thereafter, "new technologies" are required.

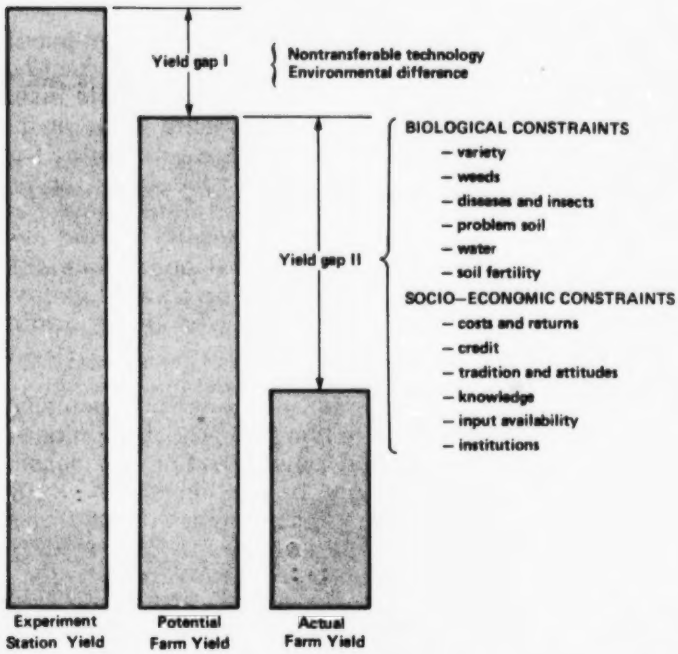


Figure 2.

Constraints to Applied Technological Advances

LONG-TERM TRENDS

In the long term (20-50 years), agricultural productivity trends are much more obscure because the determining factors themselves become obscure. Will the appropriate social-economic-political signals encourage the application of new technologies which promote more efficient agricultural production? And will these same signals stimulate the required investment in ongoing agricultural research and development? These questions cannot yet be answered.

However, a recent (1980) USDA study does suggest that an annual rate of productivity increase of one percent could be achieved over the period 1980-2030 if the rate of growth of public investment in research and extension which prevailed between 1929 and 1972 could be sustained.

With a number of major irrigation capital projects under way in the province, greater emphasis is being placed on developing crop varieties especially suited to irrigation farming.

Related Issues

This overview of research and agricultural productivity levels in Alberta leaves a number of questions unanswered. Numerous issues, by design, simply have not been addressed. These include the following:

- Are the historic productivity estimates accurate? Or are the estimates biased upward because of above-average weather conditions or other measurement errors? Some conflicting evidence exists.

- Is the agricultural research conducted in Alberta being carried out in the most efficient and effective way possible? Or are we duplicating the research efforts of other establishments across the country, ignoring other areas of urgent importance? To what extent does the freedom granted to researchers actually impede technological development? How much "academic freedom" for applied researchers can the province afford?

- In the long run (20-50 years), will the required technology actually be forthcoming? Frontier research may or may not succeed. The funding for such research is also uncertain. Even if this technology is available, will it actually be translated into productivity gains at the farm level? Given the future cost/price structure, will new technologies be practical and profitable? There are so many unknowns in this equation that **no one really knows.**

From field labour to laboratory work, agricultural research requires a wide range of skills and talents.

- Who are the actual and intended beneficiaries of agricultural research? Will technological advances continue to exacerbate income disparities within agriculture while at the same time accelerating the out-migration from agriculture — an obvious social cost? The land grant colleges in the United States have been criticized for allegedly turning a blind eye to the problems of the rural poor while simultaneously devoting considerable resources to helping agri-business and large commercial producers.

- How are research priorities actually established? Are they largely determined by the commercial payoff and/or the social payoff which might be forthcoming? Or do these priorities represent a composite ranking established by adding up the "felt needs" of the individual researchers involved?

Alberta Agriculture's Green Certificate Program provides up-to-date instruction in many new technical skills that will be required by future Alberta farmers.

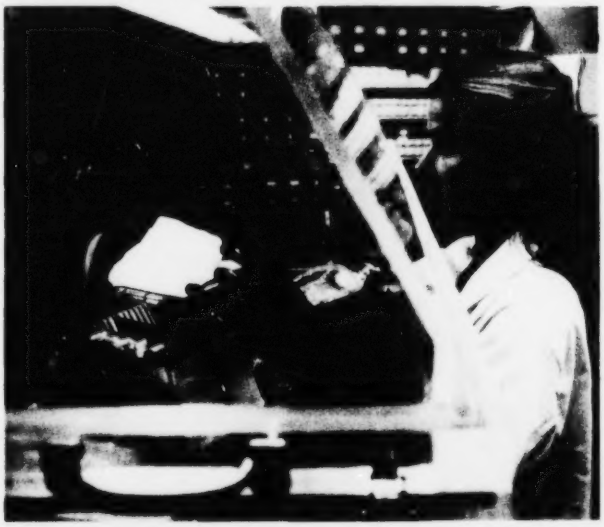
- What non-market costs and benefits of future technological advances will appear? Will some new technologies be characterized by a short-run (private) profitability which subsequently involves long-run (public) costs (as suggested by present salinity levels, land pulverization, and erosion)? For example, some of the erosion, fertility loss and soil salinity on the Prairies is attributed to the widespread use of summerfallow. In an inter-generational context, how can our natural resources be adequately protected?

Summary, Concerns and Implications

This report suggests the following:

- Agricultural productivity increases in Alberta have probably paralleled national productivity increases of about 1.5 percent per year during the period of 1950 to 1980.

- Productivity growth during the past 30 years can be largely attributed to the adoption of technologies which were more capital intensive and less labor intensive and which required improved management. Many of the capital-intensive technologies rely on the availability of inexpensive fossil fuels, e.g., gas, oil, diesel fuel, chemical fertilizers and herbicides.



A lack of adequate facilities is among the restrictions which will soon start to limit Alberta's capability to conduct agricultural research.

- Alberta-based research is generally supplemental to the vast national and international research complex which is already in place and which largely determines the broad research priorities ultimately established in Alberta. At the same time, Alberta-based research does seemingly give a high priority to research which sustains the existing capability of Alberta's agricultural industry. It is not as apparent that an equally high priority is given to research that could give future producers in Alberta a comparative advantage in the market place; nor does it appear that there is an effective mechanism to avoid duplication or to encourage the more efficient use of limited research funds.

- Research is an investment. There are no guarantees of success or that long-run (public) costs might not be associated with the adoption of the resulting technologies. At the same time, the payoff to agricultural research is, on balance, relatively high, generally even after adjusting for the indirect social costs which are sometimes incurred.

- Adequate funding for agriculture research, however, is rarely forthcoming. Since individual consumers receive only a small share of the benefits from increased farm productivity, public support for agricultural research appears to be limited. Since farmers have often failed to capture a large fraction of the long-term benefits of innovation (say 20 percent), they too are often reluctant to support large expenditures for this purpose. The situation is exacerbated by the annual funding limitations imposed on governing institutions and the lack of accountability characteristic of the research establishment itself.

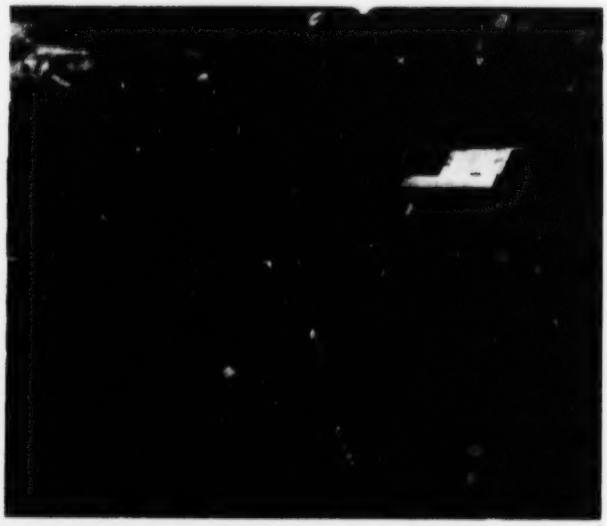
Non-agricultural use of productive farmland gives rise to some of the many serious questions that continue to face Alberta's agricultural industry.

- Ongoing "frontier" research could eventually result in large increases in future productivity growth rates, but major breakthroughs, even within a decade, are far from certain. Perhaps more significant is the apparent redirection of basic research towards more biological technology. This may acknowledge the foreseeable

limits to growth utilizing existing energy and capital-intensive technologies. Ultimately, this redirection could result in fewer demands being made upon Alberta's natural resource base.

- In the short run (5-10 years), the meagre evidence available suggests that productivity gains will not be substantially different than those of the immediate past, say 1.5 percent per annum. Perhaps one-third of this increase will be due to varietal improvements while the remaining two-thirds will rely on the adoption of "on-the-shelf" technologies.

- Over the longer term, (20-50 years), the extent of any productivity increases is uncertain. A U.S. study suggests that productivity increases of one percent per year may be possible if adequate funding for agricultural research is forthcoming. Favorable social-economic-political conditions must also prevail to ensure that the new technologies are adopted by producers.



Alberta producers have improved their productivity many times over during the past 80 years; however, even better performance is being asked of them, a demand which only new and improved technology can help them meet.